Supplementary Materials

GIS Based Road Traffic Noise Mapping and Assessment of Health Hazards for a Developing Urban Intersection

Md Iltaf Zafar 1,† ,Rakesh Dubey 1,†, Shruti Bharadwaj1, Anubhav Srivastava1, Saurabh Kr Tiwary1 and Susham Biswas 1,*

1 Geoinformatics Lab, Department of Computer Science and Engineering,
Rajiv Gandhi Institute of Petroleum Technology, Amethi 229304, India; pgi15001@rgipt.ac.in (M.I.Z.); pgi19001@rgipt.ac.in (R.D.); pgi17001@rgipt.ac.in (S.B.);

* Correspondence: susham@rgipt.ac.in; Tel.: +91-6388415537

† These authors contributed equally to this work.

Introduction:

Studies on environmental noise have shown that the fraction of the population living in noisy areas, such as around airports and on noisy streets, have an increased risk for hypertension and cardiovascular problems[1]. Cardiovascular effects are associated with long-term exposure of noise at high LAeq,24h values in the range of 65–70 dB or more, for both air- and road-traffic noises [2,3]. Hearing impairment is typically defined as a restriction in the threshold of hearing and is assessed by the range of audiometer. The ISO Standard 1999 (ISO 1990) recommends a method for calculating noise-induced hearing impairment in populations exposed to all types of noise (continuous, intermittent, impulse) during working hours[4]. Noise exposure is characterized by LAeq over 8 hours (LAeq,8h). Thus, the authors have attempted to determine the noise exposure and relate it to the associated health hazards for the road intersections.

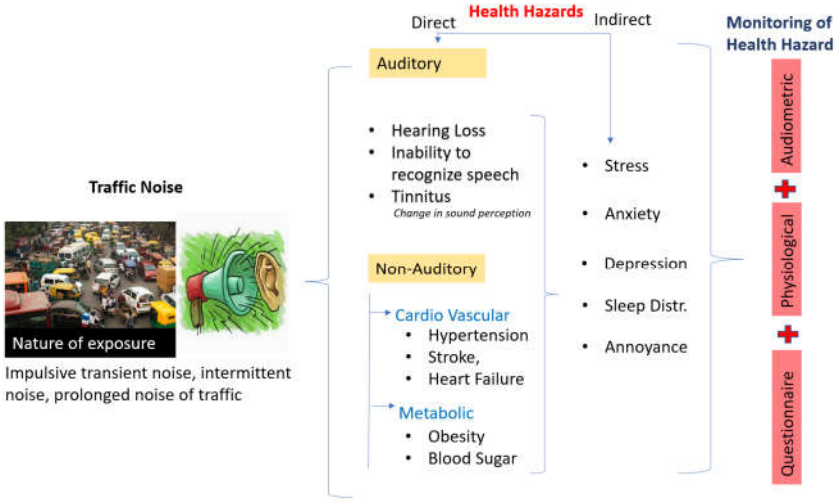

Figure S1: Noise Exposure, it's Health Hazard and Monitoring

In several countries, noise-induced hearing loss (NIHL) is also the most common occupational ailment. From 2012 to 2016, NIHL was the most frequently recognized occupational condition in Finland[5]. NIHL is the most often recognised occupational condition in Germany, accounting for 38.3 percent (n = 6951) of all recognised occupational diseases in 2019. In a study of 5 nations, including France, Spain, Italy, Germany, and Denmark, it was

discovered that NIHL was recognised as an occupational disease from 6 incidences per 100,000 people in France to 33 cases per 100,000 in Denmark. As a result, creating a healthy environment for huge numbers of people requires an awareness and recognition of the health implications of noise exposure.

It is found by recent World Health Organization (WHO) reviews of environmental noise that increased psychosocial and cardiovascular risks related to traffic noise levels varying from about forty to eighty dB(A) and a growing body of research suggests that noise exposure led to the increment in the cardiovascular disease risk [6–8].Hearing loss, on the other hand, is the most well-studied and well-understood health effect of workplace noise (Figure 1).

As per the World Health Organization, debilitating hearing loss affects roughly 30percent of all adults over the age of 65, with most of them residing in low- and middle-income nations. Congenital defects, accidents, utilisation of ototoxic medicine, and access to ecological noise can all cause hearing loss [9], but occupational exposure to noise is found to be the most frequent source of NIHL.

Occupational Health Hazards: Occupational noise-induced hearing loss is now a globally recognised work-related condition. This is the most common work-related illness in the world, impacting >10percent of all workers in developed nations[10]. So over previous 26 years, a comprehensive evaluation from China found a proportion of 21.3 percent for occupational NIHL in Chinese employees who are exposed to noise[11]. A comparable statistic was calculated for workers in the United States: between 1981 and 2010, the hearing loss frequency among noise-exposed jobs was around 20 percent. For most industry sites across the United States, though, there has been a slow but continuous decline in the noise-induced hearing loss incidence [12]. As per a WHO research, industrial exposure to noise is responsible for roughly 16 percent of debilitating hearing loss in adults globally, with the global burden of illness resulting from occupational NIHL estimated at over 4.1 million disability-adjusted years of life loss (DALY) in 2005. Nevertheless, this figure likely understates the occupational noise worldwide impact. It only includes NIHL-related burden; other health-related effects of occupational exposure to noise, such as hyperacusis or tinnitus, are not included[13–15]. Occupational NIHL is also becoming more prevalent. According to Zhou et al. [16], the health burden associated with occupational NIHL grew from 3.3 to 6 million DALYs between 1990 and 2017, with low-income nations bearing the brunt of the burden. Actual DALY data from the Institute for Health Metrics Evaluation (IHME) suggest that the burden is escalating the greatest in the Western Pacific WHO Region (which includes, for example, China, Japan, South Korea, Philippines, Australia, and New Zealand), whilst staying reasonably constant elsewhere.

In the recent six years, 5 systematic reviews on occupational NIHL have been published[10,17]. One article concentrates on asymmetric hearing loss, another on hearing loss in China [18], while the remaining three papers looked at occupational NIHL in total. [15,19,20].

A thorough analysis of occupational NIHL was undertaken by Lie et al., which included a critical evaluation of 187 papers. Despite the fact that differing criteria for defining occupational NIHL made worldwide comparisons difficult, it was discovered by the authors that occupational noise is responsible for 7 to 21percent of hearing loss. Workers in industry, shipbuilding, construction, the

military, and farming were shown to be at higher risk of occupational NIHL. Kindergarten employees were not shown to be at a higher risk, while study on professional musicians was ambiguous. In addition, exposure to impulse noise is more harmful than continuous noise, and solvents and second-hand smoke may raise the risk of NIHL, according to the research. Mazitova et al. [21] synthesised 5 reviews (counting Lie et al.) and two original investigations [22], all of which reached identical conclusions. Chen et al. [52] reviewed 108 studies published between 2000 and 2020 on the epidemiology, pathogenesis, and NIHL prevention, attempting to find that the raw presence of occupational NIHL usually ranges from 11.2 percent in a group of South African gold miners[38] to 58 percent in a group of construction workers in the United States (average age = 59.2 years) [13].

88 papers were analysed by Zhou et al.[24] on occupational NIHL in Chinese workers and discovered that workers in manufacturing, transportation, mining, and agriculture were exposed to hazardous noise levels of 98.6+/- 7.2 dB on average. Masterson et al. [25] studied the aetiology of asymmetrical hearing loss in depth. The occupational origin of asymmetrical hearing loss is also questioned because occupational NIHL is typically symmetrical. Six studies were included in this evaluation, with limited evidence of a link between occupational noise and asymmetrical hearing loss. According to the authors, physiological differences between ears or unequal shielding of one ear could make one ear more vulnerable.

Table S1. Sample Data for Leq Noise Levels

ID	X	Y	LEQ (dB)
1	81.519859	26.266251	101.6
2	81.519995	26.26623	106.3
3	81.520291	26.266185	107.2
4	81.520499	26.26615	102.9
5	81.520629	26.266303	99
6	81.520816	26.266462	91.7
7	81.520645	26.266133	102.8
8	81.521319	26.266025	96.9
9	81.521544	26.265932	96.9
10	81.521092	26.266003	107
11	81.520816	26.266064	107
12	81.520371	26.265706	93.8
13	81.520398	26.26601	98.3
14	81.520395	26.266127	102.9
15	81.52021	26.266162	107.2
25	81.520626	26.266453	43
26	81.521035	26.266473	43
27	81.520926	26.26621	46
28	81.521206	26.26617	56
29	81.521432	26.26645	43
30	81.520652	26.265865	43
31	81.520781	26.265608	47
32	81.520923	26.265854	47
33	81.52104	26.265668	43
34	81.521457	26.265728	58

Table S2. Difference of long-duration vs. short duration noise data in prediction

ID	X	Y	M1L	M2L	M3L	M4L	M5L	LEQ	LM1	LM2	LM3	LM4	LM5
1	81.51986	26.26625	81.8	99.8	84	93.3	91.6	101.6	19.8	1.8	17.6	8.3	10
2	81.52	26.26623	81.8	99.8	84	93.3	91.6	106.3	24.5	6.5	22.3	13	14.7
3	81.52029	26.26619	96.4	99.9	84	81.6	98.4	107.2	10.8	7.3	23.2	25.6	8.8
4	81.5205	26.26615	96.4	82.9	96.5	75.6	98.6	102.9	6.5	20	6.4	27.3	4.3
5	81.52063	26.2663	98.4	82.9	96.5	84.9	96.1	99	0.6	16.1	2.5	14.1	2.9
6	81.52082	26.26646	95.7	84.3	99.4	80.6	84	91.7	-4	7.4	-7.7	11.1	7.7
7	81.52065	26.26613	88.9	95.4	82.4	81.3	97	102.8	13.9	7.4	20.4	21.5	5.8
8	81.52132	26.26603	98.4	93.7	90.4	79.5	98.8	96.9	-1.5	3.2	6.5	17.4	-1.9
9	81.52154	26.26593	97.4	97.3	83	80.5	102.5	96.9	-0.5	-0.4	13.9	16.4	-5.6
10	81.52109	26.266	83.7	98.8	78.8	97.5	99	107	23.3	8.2	28.2	9.5	8
11	81.52082	26.26606	96.7	84	96.4	88.4	95.6	107	10.3	23	10.6	18.6	11.4
12	81.52037	26.26571	96.7	84	96.4	88	95.6	93.8	-2.9	9.8	-2.6	5.8	-1.8
13	81.5204	26.26601	80.9	85	75	82	76.7	98.3	17.4	13.3	23.3	16.3	21.6
14	81.5204	26.26613	92.5	75	83.6	89.3	81.8	102.9	10.4	27.9	19.3	13.6	21.1
15	81.52021	26.26616	80.6	92.9	88.5	103.6	107.6	107.2	26.6	14.3	18.7	3.6	-0.4
16	81.52004	26.26619	80.6	92.9	88.5	92	107.6	106.3	25.7	13.4	17.8	14.3	-1.3
17	81.51988	26.26621	81.1	106.2	87.2	89.8	77.9	101.6	20.5	-4.6	14.4	11.8	23.7
18	81.51968	26.26623	81.1	93	86.5	85.6	77.9	101.6	20.5	8.6	15.1	16	23.7
19	81.51984	26.26604	45.45961	69.11121	50.51029	52.93277	43.43191	69.11654	23.65693	0.005326	18.60625	16.18378	25.68463

20	81.52018	26.26606	48.82429	60.55245	56.21902	71.21732	75.21535	60.59053	11.76623	0.038074	4.371502	-10.6268	-14.6248
21	81.52001	26.2659	40.00265	40.04475	40.0163	40.03641	41.15835	43.03273	3.030085	2.987982	3.016432	2.996323	1.874381
22	81.52007	26.26638	40.01565	40.89095	40.02593	40.21593	40.14716	43.47858	3.462936	2.587633	3.452648	3.262648	3.331424
23	81.52035	26.26651	40.07528	40.16677	40.00437	40.00251	40.11872	43.09448	3.019199	2.927717	3.090116	3.091969	2.975764
24	81.52051	26.26638	64.45589	49.46198	62.56442	51.27667	62.16674	49.92767	-14.5282	0.465687	-12.6368	-1.349	-12.2391
25	81.52063	26.26645	40.20163	40.01493	40.45871	40.00637	40.01393	43.01777	2.816141	3.002844	2.559064	3.011396	3.003838
26	81.52104	26.26647	40.21684	40.01608	40.49224	40.00687	40.01501	43.01835	2.801507	3.002269	2.526102	3.011481	3.00334
27	81.52093	26.26621	57.47884	45.9677	57.18439	49.60438	56.40115	46.94743	-10.5314	0.979732	-10.237	-2.65695	-9.45372
28	81.52121	26.26617	60.60138	55.97454	52.79765	43.92115	60.99805	56.08291	-4.51847	0.108368	3.285259	12.16175	-4.91514
29	81.52143	26.26645	40.05871	40.01998	40.00936	40.00076	40.06433	43.0203	2.961594	3.00032	3.010945	3.019541	2.955972
30	81.52065	26.26587	40.14535	40.00793	40.1358	40.02181	40.11324	43.01427	2.868921	3.006337	2.878472	2.99246	2.901022
31	81.52078	26.26561	57.60447	46.06357	57.30986	49.36291	56.52615	47.02411	-10.5804	0.960539	-10.2857	-2.3388	-9.50204
32	81.52092	26.26585	58.78396	46.99411	58.48807	50.80299	57.70049	47.78519	-10.9988	0.791077	-10.7029	-3.0178	-9.9153
33	81.52104	26.26567	40.00849	40.2666	40.00275	40.19918	40.27877	43.14564	3.137155	2.879047	3.142895	2.946459	2.866878
34	81.52146	26.26573	58.92806	58.82935	45.79823	44.10735	63.98948	58.88585	-0.04221	0.056496	13.08762	14.7785	-5.10363

Table S3. Noise exposure value in one cycle of journey for visitor to noisy intersection

Point name	Noise at 1st point	Noise at 2nd point	Average noise	Noise exposure at point
a(1-2)	91.6	77.9	84.75	64.9
b(2-3)	77.9	98.4	88.15	68.3
c(3-4)	98.4	77.9	88.15	68.3
d(4-5)	77.9	107.6	92.75	72.9
e(5-6)	107.6	98.6	103.1	83.3
f(6-7)	98.6	107.6	103.1	83.3
g(7-8)	107.6	96.1	101.85	82
h(8-9)	96.1	98.8	97.45	77.6
i(9-10)	98.8	95.6	97.2	77.4
j(10-11)	95.6	95.6	95.6	75.8
k(11-12)	95.6	102.5	99.05	79.2
l(12-13)	102.5	99	100.75	80.9
m(13-14)	96.1	84	90.05	70.2
n(14-15)	84	97	90.5	70.2
o(15-16)	96.1	81.8	88.95	69.1
p(16-17)	81.8	76.7	79.25	59.4
	Total Noise exposure for 1 hours 30 minutes			90 dB

Questionnaire of workplace activities occurring.

Table S4. Questionnaire for Health Hazard determination

Name	
Age	
Gender	
Built (approximate height/weight)	
Occupation	
Address (residence/workplace) Distance of residence and workplace from centre of road) Duration of stay at workplace Duration of stay at residence (Any change in residence time in week days and weekends) For how many years working in roadside shops	
Does he/she speaks loudly (check with noise capture)	
Does he/she face difficulty in hearing (observe listening to alertness) check with noise capture	
When do you go to bed and when do you get up (try to estimate any sleeping disturbance)	
Observe general work pressure/tension in life	
Does he/she show any irritation/restlessness (nature of personality---calm/quite/poised/head shaking/ frequent hand gestures/	
Do you have any cardio-vascular illness Measure BP and Pulse rate	
Family health report: age of parent, where do they live, do your family have any disease	
When do you prefer working, i.e., at high or low traffic or crowd	
Do you prefer attending phone call/radio/TV at loud volume or low volume	
Do you have any hearing ailment (does he/she hears in both the ear equally)	

Table S5. Noise exposure value for 8 hrs.

Location	X	Y	Noise Exposure in dB (8 hrs)
1	81.51986	26.26625	93
2	81.52	26.26623	93
3	81.52029	26.26619	96
4	81.5205	26.26615	96
5	81.52063	26.2663	97
6	81.52082	26.26646	96
7	81.52065	26.26613	92
8	81.52132	26.26603	97
9	81.52154	26.26593	98
10	81.52109	26.266	94
11	81.52082	26.26606	96
12	81.52037	26.26571	96
13	81.5204	26.26601	81
14	81.5204	26.26613	90
15	81.52021	26.26616	98
16	81.52004	26.26619	98
17	81.51988	26.26621	97
18	81.51968	26.26623	87
19	81.51984	26.26604	69
20	81.52018	26.26606	60
21	81.52001	26.2659	28
22	81.52007	26.26638	28
23	81.52035	26.26651	43
24	81.52051	26.26638	49
25	81.52063	26.26645	36
26	81.52104	26.26647	43
27	81.52093	26.26621	44
28	81.52121	26.26617	56
29	81.52143	26.26645	28
30	81.52065	26.26587	43
31	81.52078	26.26561	36
32	81.52092	26.26585	47
33	81.52104	26.26567	43
34	81.52146	26.26573	58

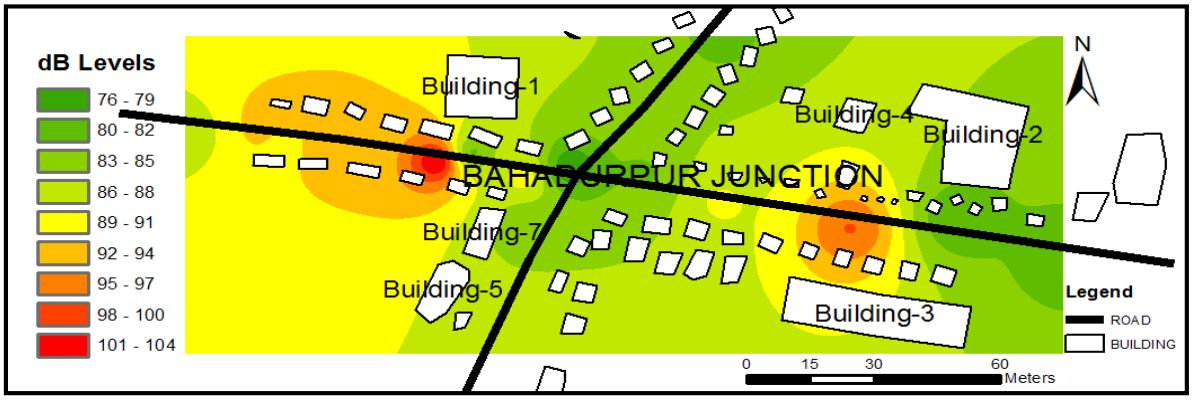

Figure: S2 Noise level mapping in a round trip at noisy crossing at 9-10.30 AM

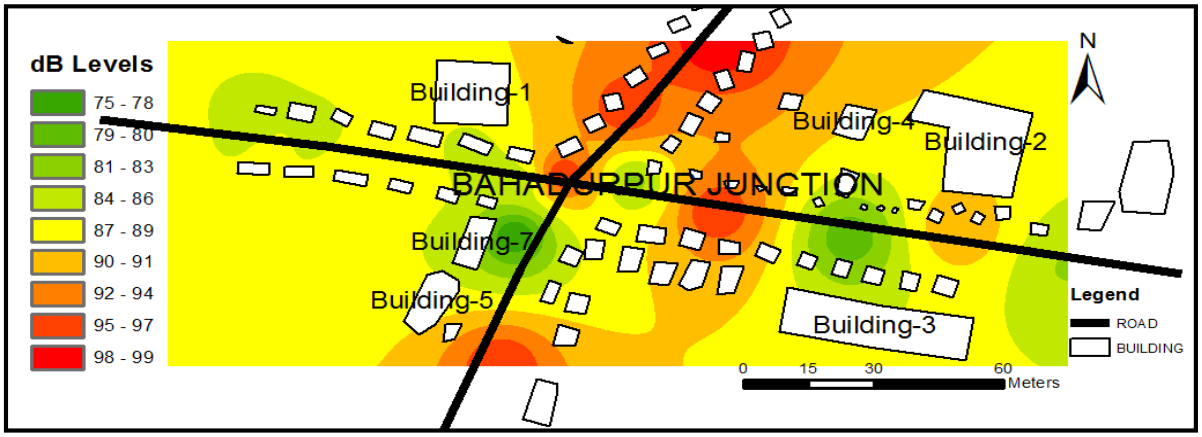

Figure: S3 Noise level mapping in a round trip at noisy crossing at 1-2.30 PM

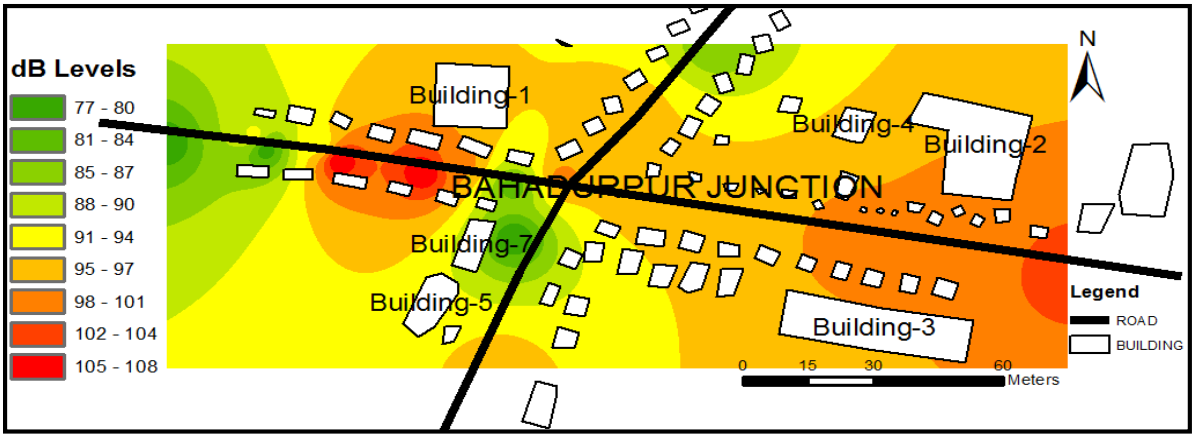

Figure: S4 Noise level mapping in a round trip at noisy crossing at 5-6.30 PM

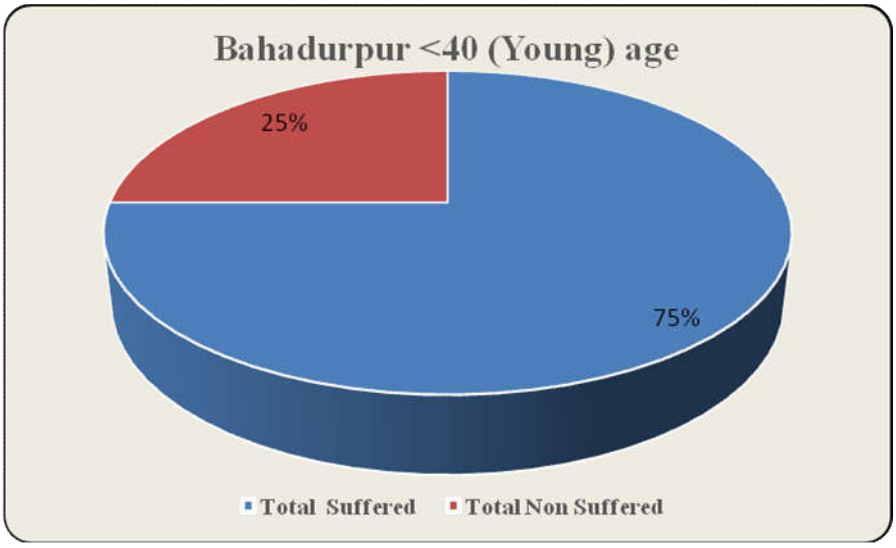

Figure S5 .Total suffering and not suffering people percentage for Bahadurpur area for <40 age group

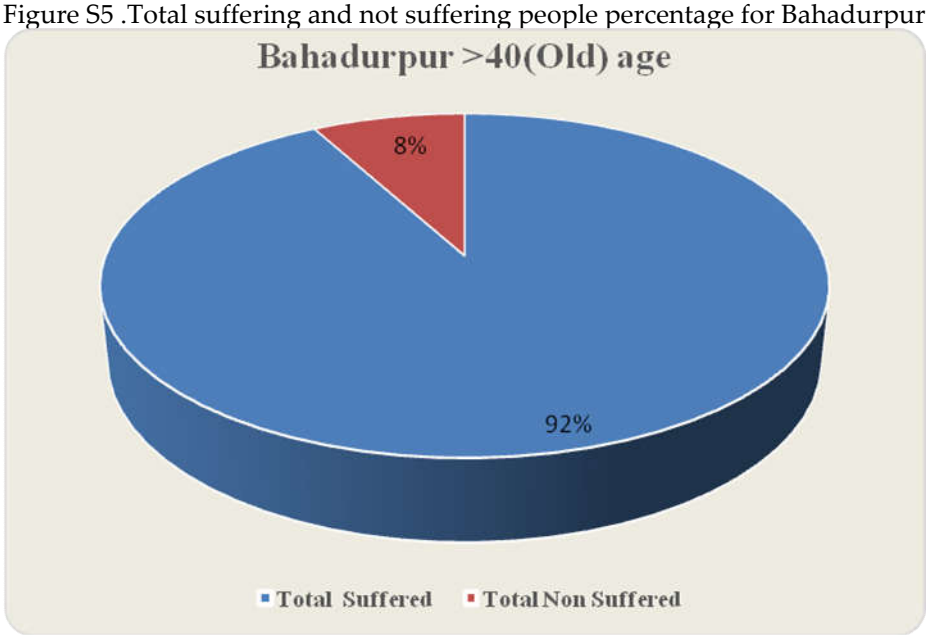

Figure S6.Total suffering and not suffering people percentage for Bahadurpur area for >40 age group

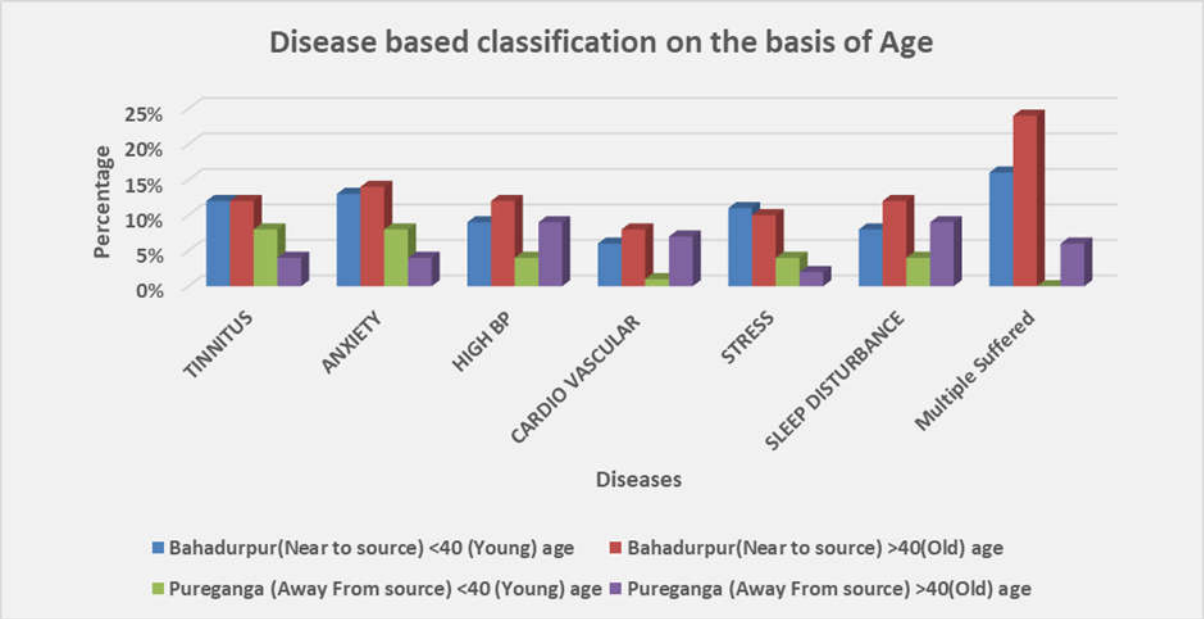

Figure S7 .Comparison of percentages of different ailments for Bahadurpur and Pureganga areas in different age groups

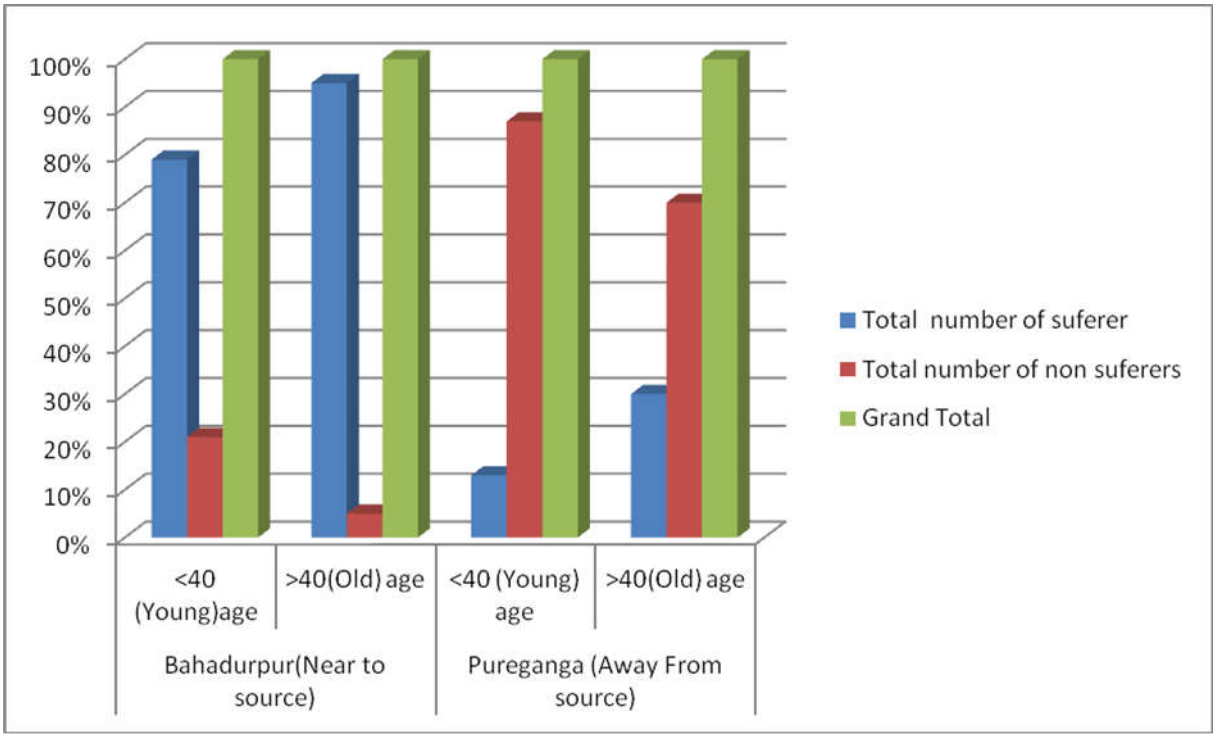

Figure S8..Comparison of percentages of different hearing impairments for Bahadurpur and Pureganga areas in different age groups

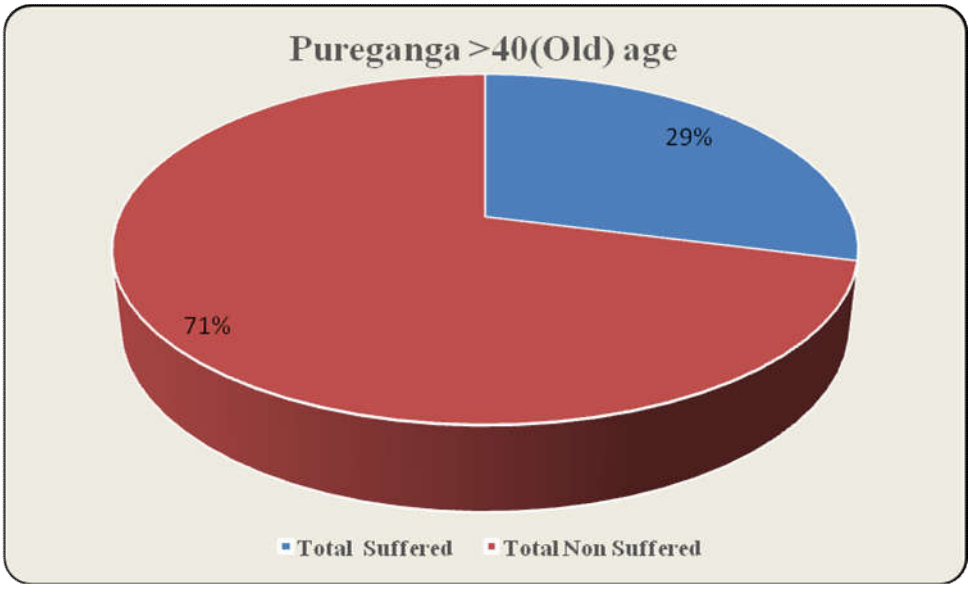

Figure S9.Total suffering and non suffering people percentage for Pureganga village in <40 age group

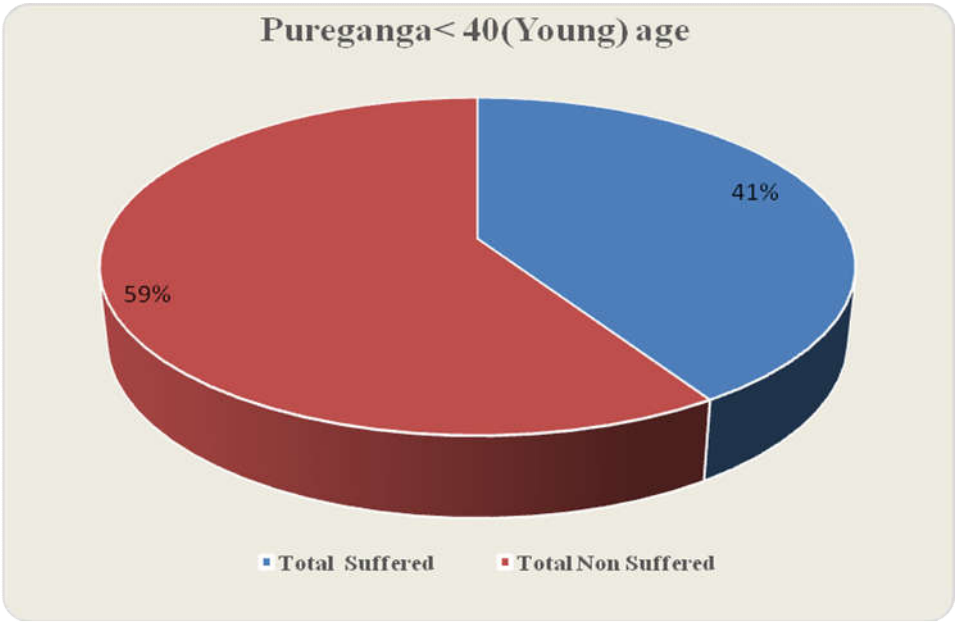

Figure S10.Total suffering and non suffering people percentage for Pureganga village in >40 age group

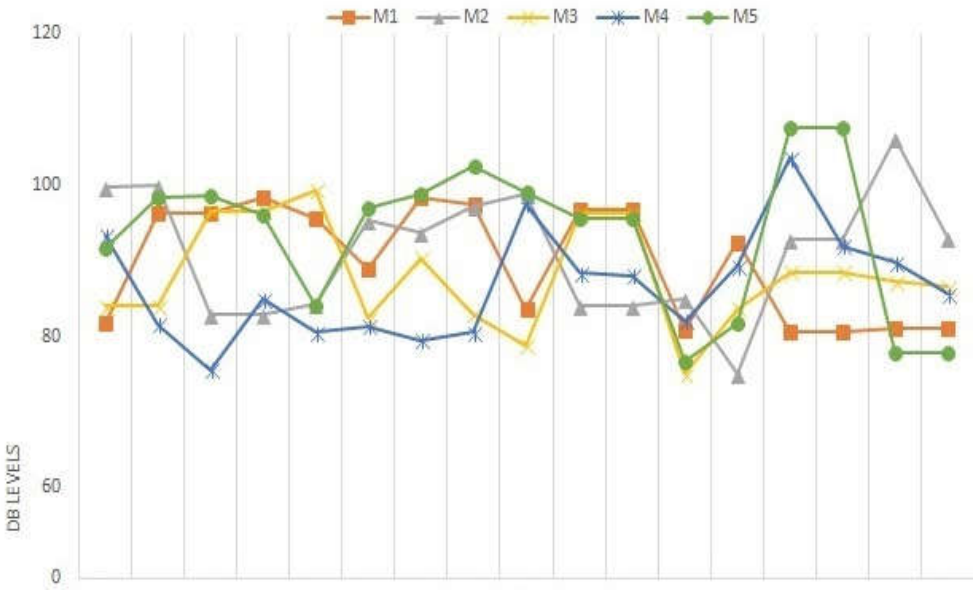

Figure S11. Variations in average noise levels over 17 road points at M1 to M5 times

Table: S6 Data Collection Schedule.

Day	Data sample collection Point and Time				
	M1 (7-9AM)	M2 (9-1PM)	M3 (1-3PM)	M4 (3-5PM)	M5 (5-7PM)
Monday	1 to 9	1 to 17	1 to 9	1 to 9	1 to 9
Tuesday	10 to 17	1 to 17	10 to 17	10 to 17	10 to 17
Wednesday	1 to 9	1 to 17	1 to 9	1 to 9	1 to 9
Thursday	10 to 17	1 to 17	10 to 17	10 to 17	10 to 17
Friday	1 to 9	1 to 17	1 to 9	1 to 9	1 to 9
Saturday	10 to 17	1 to 17	10 to 17	10 to 17	10 to 17

Additional References:

1. Dubey, R.; Bharadwaj, S.; Sharma, V.B.; Bhatt, A.; Biswas, S. SMARTPHONE-BASED TRAFFIC NOISE MAPPING SYSTEM. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.* **2022**, *XLIII-B4-2022*, 613–620, doi:10.5194/ISPRS-ARCHIVES-XLIII-B4-2022-613-2022.

2. Baliatsas, C.; van Kamp, I.; van Poll, R.; Yzermans, J. Health effects from low-frequency noise and infrasound in the general population: Is it time to listen? A systematic review of observational studies. *Sci. Total Environ.* **2016**, *557–558*, 163–169, doi:10.1016/J.SCITOTENV.2016.03.065.

3. Babisch, W.; Swart, W.; Houthuijs, D.; Selander, J.; Bluhm, G.; Pershagen, G.; Dimakopoulou, K.; Haralabidis, A.S.; Katsouyanni, K.; Davou, E.; et al. Exposure modifiers of the relationships of

transportation noise with high blood pressure and noise annoyance. *J. Acoust. Soc. Am.* **2012**, *132*, 3788–3808, doi:10.1121/1.4764881.

4. Biswas, S.; Lohani, B. Development of High-Resolution 3D Sound Propagation Model Using LIDAR Data and Air Photo. Int. Arch. Photogramm. 2008, 1735–1740.

5. Tarsha-Kurdi, F.; Landes, T.; Grussenmeyer, P. Extended Ransac Algorithm for Automatic Detection of Building Roof Planes From Lidar Data. *Photogramm. J. Finl.* **2008**, *21*, 97–109.

6. Deafness and hearing loss Available online: https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss (accessed on Apr 3, 2022).

7. Johnson, T.A.; Cooper, S.; Stamper, G.C.; Chertoff, M. Noise Exposure Questionnaire (NEQ): A Tool for Quantifying Annual Noise Exposure. *J. Am. Acad. Audiol.* **2017**, *28*, 14, doi:10.3766/JAAA.15070.

8. Noise-Induced Hearing Loss (NIHL) | NIDCD Available online: https://www.nidcd.nih.gov/health/noise-induced-hearing-loss (accessed on Jun 10, 2022).

9. Petri, D.; Licitra, G.; Vigotti, M.A.; Fredianelli, L. Effects of Exposure to Road, Railway, Airport and Recreational Noise on Blood Pressure and Hypertension. *Int. J. Environ. Res. Public Heal. 2021, Vol. 18, Page 9145* **2021**, *18*, 9145, doi:10.3390/IJERPH18179145.

10. Girard, S.A.; Leroux, T.; Courteau, M.; Picard, M.; Turcotte, F.; Richer, O. Occupational noise exposure and noise-induced hearing loss are associated with work-related injuries leading to admission to hospital. *Inj. Prev.* **2015**, *21*, e88–e92, doi:10.1136/INJURYPREV-2013-040828.

11. Plontke, S.K.R.; Dietz, K.; Pfeffer, C.; Zenner, H.P. The incidence of acoustic trauma due to New Year's firecrackers. *Eur. Arch. Oto-Rhino-Laryngology* **2002**, *259*, 247–252, doi:10.1007/S00405-002-0451-4.

12. Sonker, M.; Bajpai, S.; Khan, M.A.; Yu, X.; Tiwary, S.K.; Shreyash, N. Review of Recent Advances and Their Improvement in the Effectiveness of Hydrogel-Based Targeted Drug Delivery: A Hope for Treating Cancer. ACS Appl. bio Mater. 2021, 4, 8080–8109, doi:10.1021/ACSABM.1C00857.

13. Masterson, E.A.; Bushnell, P.T.; Themann, C.L.; Morata, T.C. Hearing Impairment Among Noise-Exposed Workers — United States, 2003–2012. *MMWR. Morb. Mortal. Wkly. Rep.* **2016**, *65*, 389–394, doi:10.15585/MMWR.MM6515A2.

14. Terefenko, P.; Wziatek, D.Z.; Dalyot, S.; Boski, T.; Lima-Filho, F.P. A high-precision LiDAR-based method for surveying and classifying coastal notches. *ISPRS Int. J. Geo-Information* **2018**, *7*, doi:10.3390/ijgi7080295.

15. WHO Burden of disease from Burden of disease from. **2011**, 126.

16. D'Alessandro, F.; Asdrubali, F.; Schiavoni, S. The Noise Abatement Plan of an Italian Road Network: A Comparison Between Standard and Innovative Methodologies. *Open Transp. J.* **2014**, *8*, 26–38, doi:10.2174/1874447801408010026.

17. Sun, X.; Sun, X. Occupational Noise Exposure and Worker's Health in China. *China CDC Weekly, 2021, Vol. 3, Issue 18, Pages 375-377* **2021**, *3*, 375–377, doi:10.46234/CCDCW2021.102.

18. Masterson, E.A.; Deddens, J.A.; Themann, C.L.; Bertke, S.; Calvert, G.M. Trends in worker hearing loss by industry sector, 1981–2010. *Am. J. Ind. Med.* **2015**, *58*, 392–401, doi:10.1002/AJIM.22429.

19. Ryan, A.F.; Kujawa, S.G.; Hammill, T.; Le Prell, C.; Kil, J. Temporary and Permanent Noise-induced Threshold Shifts: A Review of Basic and Clinical Observations. *Otol. Neurotol.* **2016**, *37*, e271–e275, doi:10.1097/MAO.0000000000001071.

20. Praticò, F.G. On the dependence of acoustic performance on pavement characteristics. *Transp. Res. Part D Transp. Environ.* **2014**, *29*, 79–87, doi:10.1016/J.TRD.2014.04.004.

21. Musiba, Z. The prevalence of noise-induced hearing loss among Tanzanian miners. *Occup. Med. (Chic. Ill).* **2015**, *65*, 386–390, doi:10.1093/OCCMED/KQV046.

22. Van Kamp, I.; Davies, H. Noise and health in vulnerable groups: A review. *Noise Heal.* **2013**, *15*, 153–159, doi:10.4103/1463-1741.112361.

23. Chen, K.H.; Su, S. Bin; Chen, K.T. An overview of occupational noise-induced hearing loss among workers: epidemiology, pathogenesis, and preventive measures. *Environ. Health Prev. Med.* **2020**, *25*, doi:10.1186/S12199-020-00906-0.

24. Yang, C.; Huang, K.; Li, Y.; Wang, J.; Zhou, M. Review for Development of Hydraulic Excavator Attachment. *Energy Sci. Technol.* 2012, *3*, 93–97, doi:10.3968/j.est.1923847920120302.386.

25. Themann, C.L.; Masterson, E.A. Occupational noise exposure: A review of its effects, epidemiology, and impact with recommendations for reducing its burden. *J. Acoust. Soc. Am.* **2019**, *146*, 3879–3905, doi:10.1121/1.5134465.

26. Saskatchewan workers compensation board www.wcbsask.com

27. Suzanne, C Purdy.; Warwick, Williams.; "Development of the Noise at Work Questionnaire to assess perceptions of noise in the workplace" The journal of occupational health and safety Australia and New Zealand, vol. 18:77-83, 2002.

28. Adventist health audiology services, Portland. https://www.adventisthealth.org

29. National Institute for Occupational Safety and Health. (1998). Criteria for a Recommended Standard. Occupational Noise Exposure Revised Criteria 1998. Cincinnati, Ohio: U.S. Department of Health and Human Services (NIOSH) Publication No. 98-126.

30. Nasim, Alnuman; Talha, Ghnimat. "Awareness of Noise-Induced Hearing Loss and Use of Hearing Protection among Young Adults in Jordan". Int. J. Environ. Res. Public Health 2019, 16, 2961; doi: 10.3390/ijerph16162961

31. Tiffany A. Johnson; Susan Cooper; Greta C. Stamper; Mark Chertoff. Noise Exposure Questionnaire (NEQ): A Tool for Quantifying Annual Noise Exposure. J Am Acad Audiol. Doi: 10.3766/jaaa.15070